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NATIONAL TRANSPORTATION SAFETY BOARD
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Forwarded to:

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SAFETY RECOMMENDATION(S)

P-85-8 through -15

At 3:30 a.m. on September 25, 1984, an explosion followed by an intense natural gas-fed fire destroyed two apartments at 3022 North 37th Street in Phoenix, Arizona. Of the 12 persons injured in the fire, 5 persons later died. After the fire was extinguished, the 1 1/4-inch-diameter plastic gas main supplying gas to the destroyed apartments was excavated and a 3-inch-long longitudinal split was discovered in the bottom of the pipe 18 feet from the gas meters on the apartment building. Gas at 30 psig had escaped through the longitudinal split, migrated into and under the apartments, ignited, exploded, and burned. ^{1/}

The pipe involved in the accident was designated as type I grade II, new service thermoplastic pipe in the Plastic Pipe Manual for Gas Service published by the American Gas Association (AGA) and was manufactured by Kerona. The pipe was a blend of acrylonitrile, butadiene, and styrene (ABS). ABS pipe is resistant to alcohols, mineral oils, and aliphatic (nonaromatic) hydrocarbons, but can be damaged by contact with acids, aldehydes, ketones, esters, and chlorinated hydrocarbons.

The Arizona Public Service Company (gas company) received all of its natural gas from one gas transmission company, El Paso Natural Gas, at five major town border stations and other smaller receipt points; the gas was neither filtered, scrubbed, nor dehydrated as it entered the gas company's distribution system. The gas company did not "fog" ^{2/} its system at any location. The gas company routinely drained liquids entrapped in the natural gas entering its distribution system at its city gate stations and other system low points; the presence of such liquids in a natural gas pipeline system is not unusual.

^{1/} For more detailed information read Pipeline Accident Report--"Arizona Public Service Company Natural Gas Explosion and Fire, Phoenix, Arizona, September 25, 1984" (NTSB/PAR-85/01).

^{2/} "Fogging" is a process of adding liquid vapor to the natural gas in a distribution system to increase its moisture content to prevent the dehydration of joint packing materials; steam or hot oils are commonly used.

The results of tests made on the pipe fracture found in the ABS plastic pipe at the accident site revealed that the pipe had deteriorated from a chemical reaction between the ABS plastic pipe and a liquid that had settled along the bottom of the pipe. It was not possible to tell how long the pipe had been deteriorating because it was not possible to determine either what the specific liquid was or how long the liquid had lain in the bottom of the pipe. The deteriorated pipe resulting from environmental stress cracking in the bottom of the pipe finally ruptured through the remaining pipe wall allowing natural gas to escape. Therefore, the pipe failure resulted from several conditions: first, a chemical action which deteriorated the pipe and produced internal cracks, and later, the internal cracks propagated through the pipe wall until finally the remaining pipe wall thickness could no longer contain the internal pressure. Without these conditions, the accident would not have occurred at that time.

The gas company installed ABS plastic pipe in its system from 1959 through 1971; its use was discontinued, according to the gas company, because the manufacturers of the ABS plastic pipe could no longer competitively meet the specifications called for by the gas company, and because it was more profitable to make ABS pipe for water usage. The gas company needed a dependable source of plastic pipe to support its distribution system expansion program in the 1960's and 1970's, and when the ABS plastic pipe manufacturers could not meet the gas company's needs, the gas company discontinued its use of ABS plastic pipe and began using polyethylene (PE 3306) pipe plastic pipe for its service lines and polyvinylchloride (PVC) plastic pipe for its gas mains of up to 2 inches in diameter. Later, the gas company began using PE 2306 pipe as a replacement for both the ABS and PE 3306 pipe. The PE 2306 pipe is still being used by the gas company.

The gas company leak records are neither computerized for rapid retrieval nor studied for statistical analysis or trending. Most of the leak records are stored in boxes in a company warehouse, and a comprehensive leak record search would involve the examination of thousands of records, many of which are written in longhand. Each record would have to be analyzed before a meaningful tally could be produced. Most of the older leak records involve steel pipe; the plastic pipe leak records considered reliable by the gas company cover the period from 1971 to the present. A gas company representative said that the gas company relied upon field reports from the maintenance crews and the judgment of its management staff concerning these field reports to determine whether certain types of pipe had serious leakage problems that needed systemwide attention. He stated, as an example, that the gas company made a determination at a meeting with the Arizona Corporation Commission (commission) on November 24, 1981, that a problem existed in its PE 3306 plastic pipe and that it would begin a replacement program. This determination was reached not by an analysis of records of ABS plastic pipe leaks, but by the collective memory of the foremen and superintendents who had seen the leaks and had shared their information. The problem with the PE 3306 pipe was determined to be premature aging wherein some of the pipe developed cracks or splits allowing the escape of gas. At that time the gas company had approximately 40,000 PE 3306 plastic pipe service lines in its system. By September 1984, approximately 30,000 of those service lines had been replaced with PE 2306 plastic pipe, and by March 1985 replacement was complete.

Title 49 CFR 192.723 requires that leakage surveys of the distribution system outside of the principal business area be made as frequently as necessary, but at intervals not exceeding 5 years. By March 1984, the gas company was inspecting its entire system annually while the replacement program was underway. After the accident, the gas company again accelerated its leak survey program, and leak survey crews began operating on a 60-hour workweek, 50 percent more than the normal 40-hour workweek used before the accident; this provided for more than the annual inspection.

Gas company records for its ABS plastic pipe show that there was one failure each year in 1972, 1973, and 1974, and 95 failures from 1977 through 1983, of which 25 were required by 49 CFR 191.5 to be reported to the U.S. Department of Transportation (DOT) because the leaks resulted in ignition, deaths, injuries, or other reportable criteria. The 95 failures include only instances of material failure and do not include failures caused by events such as excavation damage, tree root damage, or line pull-outs.

The gas company told the commission in 1982 that it intended to replace all 3- and 4-inch-diameter ABS plastic pipe because the company could no longer find a supplier for these sizes and because, if a failure did occur in these ABS pipe sizes, it would be difficult to shut off the flow of gas to the failed section and difficult to replace the failed section with a PE-type pipe and reconnect it to the ABS pipe; there is a possibility of splitting ABS pipe of this size when squeezing it off. The commission noted that between 1972 and 1981 it had been notified of only two ABS pipe failures of the 3- and 4-inch-diameter sizes. The gas company had not replaced any of the ABS pipe at the time of the September 25, 1984, accident. After the accident, the gas company informed the commission that laboratory analysis of some of the previous ABS pipe failures indicated premature aging and that the gas company was commencing a replacement program.

At the time of the accident, the gas company was negotiating for the sale of its entire gas distribution system to the Southwest Gas Corporation. The sale was made on November 1, 1984, and the gas company has agreed to help Southwest Gas Corporation finance the replacement of up to 2,400 miles of prematurely aging plastic pipe in the system. Most of the gas company personnel, both supervisory and nonsupervisory, are now employed by the Southwest Gas Corporation.

The operating pressure in the area of the accident always had been 30 psig, and it was not reduced after the accident when the new pipe was installed. However, after the accident, the gas company reduced the operating pressure in other areas of the system where ABS plastic pipe was in use from 39 psig to 30 psig, a pressure reduction of approximately 25 percent. According to the gas company, the pressure reduction was made to prevent, or reduce the number of, similar ABS plastic pipe failures.

Pipeline leak records provide an important source of information to a pipeline operator concerning the physical condition of the gas distribution system. Leak reports, aside from showing where the leaks occurred so that permanent repairs or replacement can be undertaken at a later date, are examined by prudent pipeline operators to determine the number, frequency, and distance of leaks in areas and to determine whether problems, such as corrosion, material failure, and improper installation exist. When making subsequent repairs or replacements, the operator should examine the pipe on either side of the leak and determine its condition. By carefully monitoring reliable leak records, the operation and maintenance departments, together with the engineering departments, often can determine the emergence of a problem before many leaks occur and thereby can rectify or mitigate the conditions before a serious accident occurs. Leak records, and their accuracy and availability, are of prime importance in pipeline operations; unanalyzed leak records filed in boxes in a company warehouse cannot provide readily available information and are virtually worthless.

If the gas company had established, as Federal regulation 49 CFR 192.617 requires, "procedures for analyzing accidents and failures, including the selection of samples of the failed equipment or facilities for laboratory examination, where appropriate, for the purpose of determining the causes of the failure and minimizing the possibility of a recurrence," systematic study of the ABS plastic pipe failures in 1972, 1973, or 1974

would have alerted the gas company to problems developing in the ABS plastic pipe sections of its distribution system. If these pipe failures had been analyzed in a laboratory at that time, the gas company would have learned that the pipe was reacting with liquids in the system and could have determined where the liquids were coming from and how to exclude them. At the same time, the gas company could have been draining any liquids from known low spots in its system, analyzing these liquids to determine if they were reacting with the ABS plastic pipe, and determining the extent of the problem. Such action would have given the gas company at least a 10-year headstart on a pipe replacement program, a pressure reduction program, and a leak survey program. Replacement pipe could have been installed on a yearly basis, commencing in the areas of the first three failures, instead of in a crash program that followed after this accident. If these things had been done--early failure analysis, drainage and analysis of liquids, the decision to replace the ABS plastic pipe, and reduction of pressure on the ABS part of the distribution system--the gas company might have been able to replace the ABS pipe before the accident at North 37th Street occurred. In addition, and perhaps more importantly, the gas company could have disseminated its newly discovered information on ABS plastic pipe deterioration to its pipe suppliers, to the AGA, and to other gas pipeline operators at regional meetings. This information would have given everyone a headstart on identifying and solving their individual problems or might have deterred them from installing any more ABS plastic pipe until more was known about the problem. The Safety Board believes that Federal regulation 49 CFR 192.617 was developed to achieve this end. The Safety Board finds that other gas companies also are lax in sending failed pipe for laboratory analysis, and the Board believes that the Federal regulations should be enforced more strongly.

The Phoenix Fire Department's Standard Operating Procedures, M.P.209.03, Tactical Plans Hazardous Materials, provide a basic philosophy and strategic plan for emergencies involving hazardous materials. The department's Hazardous Incident Response Team (HIRT) members are provided training in a variety of hazardous materials situations including fires, spills, transportation accidents, chemical reactions, and explosions. The training includes the identification of hazardous materials, the containment of the hazardous materials, the evacuation of a contaminated area, the establishment of security around a hazardous area, and the stabilization and/or removal of the hazardous material. HIRT personnel are instructed in how and when to use combustible gas indicators (CGIs) in gas-related accidents, how to detect gas leaks visually, and how to work with and use gas company employees to pinpoint leaks and shut off the gas supply. The gas company did not provide any training to the fire department nor did the fire department request such training. However, individually some fire department personnel have accompanied gas company personnel in responding to leak calls and gas odor complaints.

Early in 1984, because of a misunderstanding concerning when, during the course of investigating a gas leak, the gas company should notify the fire department, the gas company and the Phoenix Fire Department drew up a Memorandum of Agreement. Fire department and gas company personnel met to clear up the communications misunderstanding and to set down in writing the circumstances in which the fire department would be notified of a gas leak. The gas company procedures were amended in May 1984.

The fire department's response to the fire was rapid. Firefighters correctly allowed the gas-fed flames to burn out in the ground rather than extinguishing them and risk allowing the natural gas to accumulate and reignite. However, the fire department's HIRT team did not use its CGIs correctly to determine the extent of gas migration and the extent of the gas hazard because they tested only in the open air and not within the ground around the apartments or other confined spaces.

Gas company personnel who first responded were excluded from the accident area first by the fire department and later by the police department and were therefore unable to determine, through their own investigation, the extent of gas leakage and the leak location. Nevertheless, the gas company "troubleman" should have specifically informed the first firefighter who barred him from the site that it was necessary for him to investigate to determine the extent of the hazard and that he had the expertise to do so. Unfortunately, the "troubleman" did not do so. The gas company personnel should have been used by the fire department as "experts" in leak search activities and should have been assisted by the fire department in the rapid pursuit of their work. If lack of protective clothing (including breathing equipment) was a factor in barring the "troubleman" and other gas company employees from the accident area, the clothing should have been provided. Firefighters did not realize the potential for additional gas fires or explosions because they had not probed in the ground with CGI's to determine more precisely the extent of gas migration, and they did not know where the gas was coming from.

The HIRT team used CGI's in apartment Nos. 7 and 8 to test the atmosphere. While the readings in the apartments both close to the floor and close to the ceiling showed no gas, gas may have been migrating into these buildings through the soil and within the walls and yet not have entered the apartments. The more responsible action by the fire department would have been to aid gas company personnel using CGI's by assigning, for example, two of the four HIRT team members to help the gas company employees and to obtain more gas in-soil readings. Such actions would have resulted in firefighters learning the extent of the gas migration more rapidly. Although the lack of cooperation and coordination between the fire department and the gas company did not prolong the fire or hinder the firefighting activities in this particular instance, under different conditions it could have proven catastrophic. The Memorandum of Agreement which both parties had previously adopted proved worthless because the fire department had not promulgated implementation procedures prior to this accident.

Therefore, the National Transportation Safety Board recommends that the Southwest Gas Corporation, as successor to the Arizona Public Service Company:

Continuously sample the natural gas stream at its town border stations for entrapped liquids, check the chemical composition of any liquids collected to determine their effects on ABS or other types of plastic pipe, and if indicated filter or otherwise remove these liquids before they enter the gas distribution system. (Class II, Priority Action) (P-85-8)

Periodically check for liquids accumulated at the low spots in its gas distribution system, remove any liquids found, and chemically analyze the liquids to determine their potential for deteriorating ABS or other types of plastic pipe. (Class II, Priority Action) (P-85-9)

Expedite the replacement of the ABS plastic pipe in its gas distribution system, beginning with known areas of liquid accumulation and other known low spots. (Class II, Priority Action) (P-85-10)

Continue its expedited leak survey program in all areas of its distribution system containing ABS plastic pipe until all of the ABS plastic pipe has been removed. (Class II, Priority Action) (P-85-11)

Operate the sections of its system using ABS plastic pipe at the lowest feasible pressure until all of the ABS plastic pipe has been removed. (Class II, Priority Action) (P-85-12)

Expedite the computerization of its leak reports to permit their rapid retrieval for review, analysis, and identification of potential material problems in its gas distribution system. (Class II, Priority Action) (P-85-13)

Establish failure analysis procedures in conjunction with computerizing its leak report system, to more rapidly detect and correct gas distribution piping problems. (Class II, Priority Action) (P-85-14)

Review with its dispatchers and operating personnel who routinely handle leak incidents, the Memorandum of Agreement with the Phoenix Fire Department, and emphasize the importance of coordinating and cooperating with firefighters. (Class II, Priority Action) (P-85-15)

The National Transportation Safety Board is an independent Federal agency with the statutory responsibility "... to promote transportation safety by conducting independent accident investigations and by formulating safety improvement recommendations" (Public Law 93-633). The Safety Board is vitally interested in any action taken as a result of its safety recommendations. Therefore, it would appreciate a response from you regarding action taken or contemplated with respect to the recommendations in this letter.

BURNETT, Chairman, GOLDMAN, Vice Chairman, and BURSLEY, Member, concurred in these recommendations.


By: Jim Burnett
Chairman